DISCUSSION OF A. STREIFF'S "THE PRACTICAL IMPORTANCE OF CLIMATIC CYCLES IN ENGINEERING" [1]

By J. W. SHUMAN, M. Am. Soc. C. E.

I should like to comment briefly on the work done by Mr. Streiff, as evidenced by his contributions to this REVIEW. In July, 1926, Streiff came forward with a complicated mathematical exposition of curve "smoothing," leading to a new method of separating the component elements of a rainfall or run-off graph. This article also pointed out a correlation between Wolf numbers, run-off, and lake levels, and ended with one example of treating river run-off data. Various cycles were derived from the river run-off graph, including Brückner cycle, 11-year cycle, and cycles of 3 years, 1.63 years, 12 months, 6 months, and a variable cycle of 2 to 5 months. Some months later an article appeared in the REVIEW, written by a well-known engineer, attacking this concept of Streiff's, of cycles in rainfall and run-off data, and claimed, in substance, that there was nothing to the idea, that there were no cycles in rainfall data, and that it was extremely improbable that run-off could be predicted by any such means.

Streiff's second article appeared in the March, 1928, number of the REVIEW, entitled "Notes on Estimating Run-off." This article followed up his first study, in a practical manner, and gave a concrete example of application of his "Strato" Analysis to the Manistee River in Michigan. This time, however, Streiff has shortened his procedure by combining the 11-year, 3-year, and 1.63-year cycles all into one residual, called residual "*e*." (Please note one typographical error in March, 1928, article—the residual "*c*" in second line of seventh paragraph from top of first column, page 99, should be, residual "*e*.") This article put the matter in such shape that it could be easily followed by anyone interested who desired to investigate for himself.

Streiff's third article appeared in October, 1929, and shows in considerable detail just why these faint cycles in our weather elements are useless for day-to-day weather forecasting, but are invaluable aid, in hydrological studies, coining a new expression "Climatic engineering."

I give the above brief sketch to point out the fact that it is now nearly four years since the initial appearance of Streiff's cycle ideas, and yet seemingly few hydrologists have made due investigation of the subject. It is true that there are selected groups here and there who are studying into these modern methods, but the rank and file are still plodding along, using the old reliable accepted theory of chance for occurrence of run-off and floods.

I wish to commend Mr. Streiff for his ability and mental powers, the results of which are now given to the profession at large. Streiff's first article made a great impression on the writer. Since then his methods of analysis have been sufficiently studied to use them with confidence. Until one is willing to actually go through with one of these analyses step by step and see the cycles emerge from the raw data only a faint conception can be had of what really can be accomplished.

There appears to be some skepticism of the Brückner cycle being in truth the double sun-spot cycle that, although the same cycle can be derived from rainfall and run-off data, it may not necessarily have any relation to the sun-spot cycle. Further testing and trials with various rainfall and run-off data will doubtlessly settle all such differences of opinion as time goes on. Personally, the writer has investigated at least three rainfall stations in every State in the Union and in a great many in Europe and has found the Brückner cycle, as pointed out by Streiff in every such station. It is true the amplitude of the cycle is sometimes very slight. But in this case it can be magnified by proper multiplication, with a large constant, to bring its swings into visibility. This double sun-spot cycle derived from the Wolf numbers, then, furnishes us with a pattern curve, with which comparison can be made by similar curves derived from rainfall and run-off data.

The writer can also testify as to use this analysis can be put to in considering lake levels. In March, 1928, the writer made a "Strato" analysis of the levels of Lake Ontario, taking the monthly mean levels as listed by the district engineer's office at Detroit. The mean level for the year 1927, was 245.55; and a letter was sent to Mr. Alfred J. Henry, editor of the MONTHLY WEATHER REVIEW, early in April, 1928, predicting that the mean level for the year 1928 would be 245.90. The level for the year actually turned out to be 246.20. In a letter written in April, 1928, to Lieut. Col. George B. Pillsbury, then district engineer at Detroit, the statement was made: "In addition to predicting the 1928 mean level of Lake Ontario, I also venture to state that the 1929 mean level will be at least equal to the 1928 mean level, if not actually higher."

In view of the writer's own experience, then, he urges hydrologists to study these articles in good faith and to peruse the subject until a working insight is gained. With the acceptance of these principles, we are now provided with means of forecasting a year ahead of time a river run-off, water supply, etc. The next great step is to study the monthly peaks of rainfall and run-off. When we can foretell their occurrrence as well as we can the total run-off for the year we shall then have the question of floods solved. I may point out some of the difficulties that stand in the way of our understanding of the subject.

The peaks of rainfall or run-off occur 2, 3, 4, or 5 months apart, when isolated out of the original graph, and constitute the "Clough" cycle—a variable cycle of a mean value of some 28 months. It may be accepted that this cycle is due purely to fortuitous storms, and hence can not be further understood, or that it may follow in sequence some "cause" of approximate periodicity. Whatever the facts are, we do know that the peaks of this cycle mean higher than normal values for the data.

Streiff shows the reduction of the original monthly mean run-offs to a residual "*e*." The mean ordinate of this residual "*e*" for the year represents the mean monthly flow. But the value of any monthly ordinate of this residual "*e*" does not necessarily represent that particular month's mean flow. If $R\,1, R\,2, R\,3, \ldots R\,12$ represent the 12 ordinates of the residual "*e*", and $a\,1$, $a\,2$, $a\,3$, . . . $a\,12$, the difference between each monthly mean flow and the residual ordinate, we have—

$$(R\ 1+a\ 1)+(R\ 2+a\ 2)+\ \ldots\ (R\ 12+a\ 12)=\text{total year's run-off.}$$

But

$$R\ 1+R\ 2+\ \ldots\ R\ 12=\text{total year's run-off.}$$

Hence,

$$a\ 1+a\ 2+\ \ldots\ a\ 12=0.$$

[1] Monthly Weather Review, Oct., 1929, vol. 57: 405-411.

We note that the run-off at each month is made up of a residual plus a variable (*a*), which may be plus or minus in value, and the only thing we know about these variables is that their sum for the year is zero.

The Clough cycle probably does follow a similar cycle in the sun-spot numbers, but the correlation coefficient between the rate of change of sun-spot numbers and this variable cycle in run-off is only between plus 0.50 and plus 0.60—not good enough to work with.

It is the hope of the writer that these articles of Streiff will prove a stimulus to the profession, who owe it to themselves to at least investigate what might be to their benefit. Possibly within 10 years' time we will treat with simplicity what seems to us now a hard nut to crack.

FURTHER STUDIES ON THE ELECTRICAL CHARGES OF THUNDERSTORMS (A REPORT OF PROGRESS)

By J. C. JENSEN

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Increased interest has been shown in the phenomena connected with lightning discharges during the last three years, due to the controversy between Simpson and C. T. R. Wilson in England and to the tremendous property losses caused by lightning in the United States. It should be remarked also that in the background behind any investigation of this kind is its relation to the earth's negative charge.

Simpson, in 1909, proposed what is known as the "breaking-drop theory" of the origin of electricity in thunderstorms which depends on rapidly ascending currents of air in a thunderhead and the observed fact that when a drop of water is broken up in the air the drop becomes charged positively and the air negatively. Raindrops from the active portion of such a cloud should carry positive charges and those from its more remote portions negative ones.

C. T. R. Wilson, by the use of an insulated ball and a capillary electrometer, succeeded in measuring the changes in the earth's field due to lightning and gave a ratio of 1 to 1:56 for positive to negative discharges. The more recent investigations by Schonland and Craib in South Africa (**1**), (**4**), (**5**), with apparatus essentially similar to Wilson's, give results in good agreement, both of them holding to the opinion that the lower pole of a thundercloud carries a negative charge.

In May, 1926, Simpson published a paper in which he maintained that a lightning flash originates only in the region of the maximum positive electric field and that any branching of the discharge will be in the direction of the seat of negative charges. He used as evidence on this point a large number of photographs of lightning flashes, of which 328 indicated that they were from positive clouds and 89 from negative. In April, 1927 (**2**), and more recently in November, 1929 (**3**), he gave a revised and amplified version of his theory of thunderclouds, in which he shows that the space charge of cloud should be positive in the active vortex, but that by far the larger portion of it should be negative. Lightning discharges are divided by him into three groups—(*a*) upward discharges from the head of the ascending air currents; these are thin, usually hidden by the cloud, and, if seen, would be branched upward. (*b*) Downward discharges from the same region, also thin, and branched downward. (*c*) Heavy flashes from the ground upward to the more quiescent part of the cloud. Where branching can be seen these are, branched upward.

Our present series of observations at Nebraska Wesleyan began more than five years ago. Two papers have been read before this society (**6**), (**7**), and one before the American Physical Society (**8**), all in the nature of progress reports, for the problems involved are many and difficult of solution. The apparatus used consists of an insulated metal deck 9 meters above the earth, on the roof of the gymnasium which is adjacent to the physics laboratory. The deck is about 3 by 4 meters in size and has a capacity of 0.0014 microfarad. Adjacent to the deck is an insulated wire rectangle of the same dimensions as the deck and having a capacity of 0.0007 microfarad. Wires connect these conductors to earth through a sensitive galvanometer. A right-angle prism and rotating drum are used for making the records, the pencil carried by the parallel rods being kept over the spot of light by the observer. The capacity of the system and the ballistic constant of the galvanometer having been determined, the change in potential of the deck due to a given discharge may be computed. Values of changes in the potential gradient thus obtained have been consistently lower than those of other observers, due to tall trees and other surrounding objects.

In order to be able to identify a given discharge with the corresponding galvanometer deflection, a pair of telephone wires was run to the top floor of an adjoining 4-story building which presents a good view toward the western horizon. At the instant of a flash, word is sent to the observer in the laboratory, who records the data given on the drum. Differentiation is made between flashes from cloud to cloud and from cloud to earth. Notations are entered in a notebook of each lightning discharge regarding distance to cloud, size of flash, part of cloud from which flash came, etc. Likewise, when photographs have been taken, notes taken at the instant are used, together with the drum record and synchronized watches, to identify the picture.

During the season of 1928 observations were made on a total of 19 storms, 11 of which were in daytime and 8 at night. A total of 1,014 galvanometer deflections resulting from lightning discharges were recorded, 639 of which indicated a decrease of negative potential above the apparatus and 375 an increase of negative or a decrease of positive. Classifying as "distant" discharges beyond 8 kilometers and as "intermediate" those from 5 to 3 kilometers, the totals are 177 negative to 122 positive for distant discharges, 171 to 67 for the intermediates, and 298 to 196 for the "near" ones. It has here been assumed that our clouds hang lower than those observed by Schonland in South Africa, hence the reversal distance should be less than the 6.8 kilometers which he found. The fact that the ratio is larger for the intermediates than for the near ones would indicate either that this assumption is not well founded or that Wilson's theory does not account for all the facts. It should also be noted that the observations made prior to 1928 totaled 639 negative to 375 positive, a ratio practically identical with the more recent one, although no special efforts to check on distances were made in the earlier readings. Wilson's totals in his earlier paper gave a ratio of 1 : 1.56, positive to negative, while my present aggregates of 1,096 and 1,979, including the 1929 season, give a ratio of 1 : 1.80. In view of the radical difference in method